THE MONTHLY NEWS MAGAZINE OF THE NATIONAL BUREAU OF STANDARDS August 1975

DIMENSIONS NBS

A PUBLICATION OF THE UNITED STATES DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

DIMENSIONS NBS

August 1975 / Vol. 59, No. 8 / ISSUED MONTHLY

CONTENTS

Nat. Bur. Stand. (U.S.) DIMENSIONS/NBS
CODEN:DNBSBG 59(8) 171-192

Superintendent of Documents Catalog No. C13.13:59/8

Library of Congress Catalog No. 25-26527

COVER: NBS has a history of working for railway safety that goes back 60 years. Today's focus is on helping to alleviate the hazard posed by exploding tank cars. For the full story, see the article beginning on the opposite page.

U.S. DEPARTMENT OF COMMERCE
Rogers C. B. Morton, Secretary
Betsy Ancker-Johnson
Assistant Secretary
for Science and Technology
NATIONAL BUREAU OF STANDARDS
Ernest Ambler, Acting Director
Prepared by the NBS Office of
Information Activities
Washington, D.C. 20234
William E. Small, Chief
Richard S. Franzen,
Chief, Editorial Section
Sharon A. Washburn,
Managing Editor
Juli Kelley,
Associate Editor
Contributing Editors
L. Kenneth Armstrong, Dottie Hafer
Kent T. Higgins, Leslie A. Horn,
Madeleine Jacobs, Stanley Lichtenstein,
Frederick P. McGehan, R. David Orr,
Alvin L. Rasmussen, Arthur Schach,
Collier N. Smith, Carol M. Sussman
Visual Editor
Richard E. White

The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:
The Institute for Basic Standards
The Institute for Materials Research
The Institute for Applied Technology
The Institute for Computer Sciences and Technology
Center for Radiation Research
Center for Building Technology
Center for Consumer Product Technology
Center for Fire Research

Formerly the TECHNICAL NEWS BULLETIN of the National Bureau of Standards.
For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription: Domestic, $9.45, foreign, $11.85, single copy, 80 cents. The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 30, 1976.

Working for Railway Safety

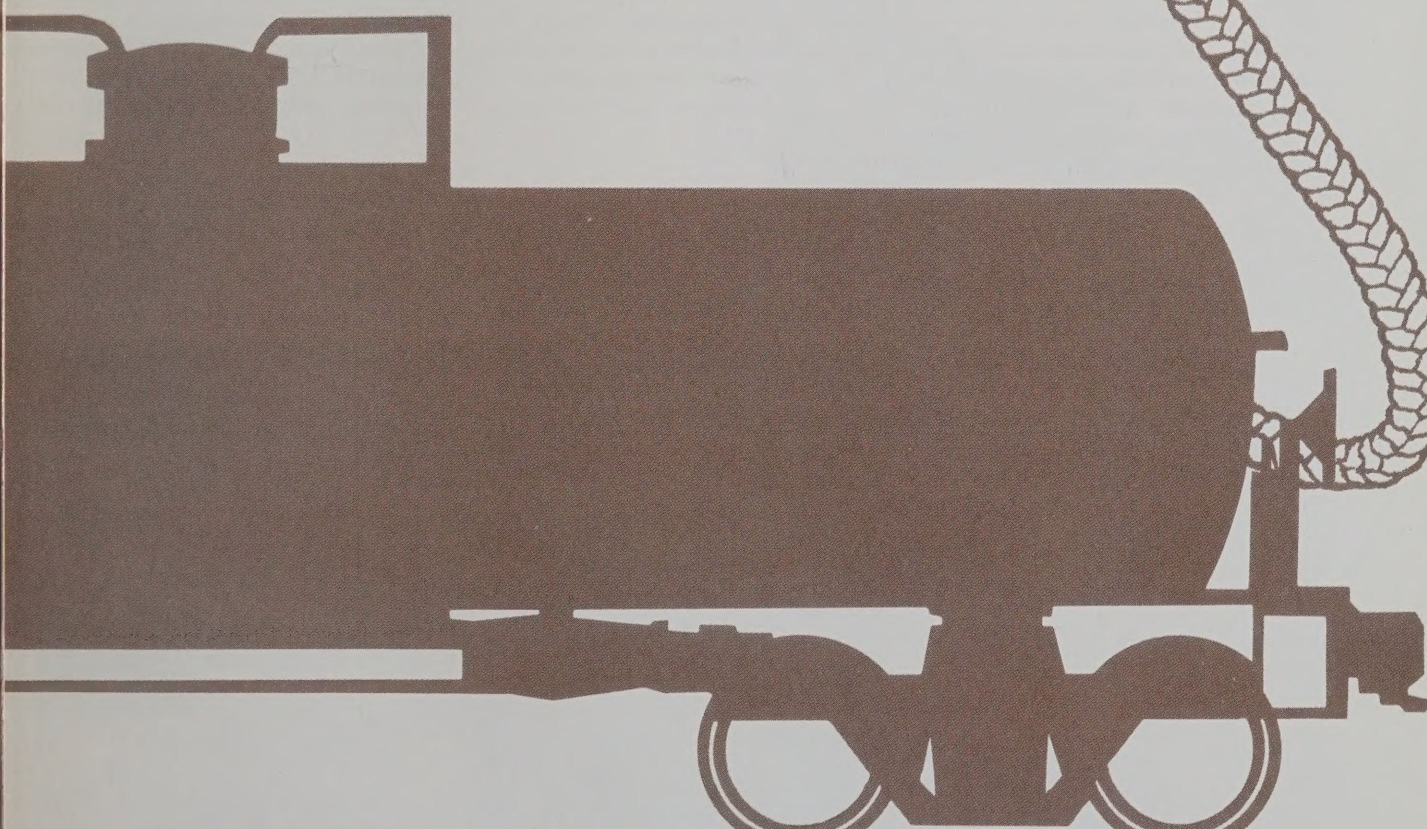
AT the grade crossing, a freight train goes rumbling by at 3 o'clock on a quiet Sunday morning.

Eighty-one cars long, it carries cotton, clothes, lumber, chemicals, wine, what have you. . . .

There are a number of tank cars carrying chemicals. Two smaller cars are loaded with acrylonitrile, a corrosive, highly flammable chemical used in the manufacture of synthetics.

Suddenly, something goes wrong. Fifteen cars are derailed. A fire erupts, quickly mounting to skyscraper height as it is fed by chemicals and asphalt. Local authorities, not knowing "what we have on our hands" and fearing the possible spread of poisonous gases, rouse the countryside with bullhorns and sirens and evacuate the populace from the village a kilometre away. In the end, no one is hurt, but damages exceed a quarter of a million dollars. The disrupted community is Docena, Ala., February 18, 1973.

turn page



Things could have been worse. In railroad tank car accidents near other communities, there have been deaths and injuries plus damages mounting as high as the $10 million range or possibly more, contrasting with Docena's relatively light $¼ million estimated loss. Acrylonitrile is less widely used and typically is carried in smaller quantities than some other dangerous materials such as liquefied propane, petroleum, or vinyl chloride monomer. Such cargoes may move in "Jumbo" pressure cars of 125,000-liter (33,000-gallon) capacity.

Houston, Tex., for example, suffered a derailment involving tank cars on October 19, 1971. Of 20 derailed cars, six contained vinyl chloride monomer and two contained other hazardous materials. Pieces of violently rupturing tank cars flew 90 metres (300 feet) through the air. One firefighter was killed and 40 persons, mostly firefighters, were hurt.

Much of Crescent City, Ill., was destroyed on June 21, 1970, when ten liquefied-petroleum-carrying tank cars ruptured and burned, propelling tank sections up to 600 metres (about 2,000 feet) from the tracks. There were 11 serious injury cases.

At Laurel, Miss., on January 25, 1969, tank car sections weighing as much as 13.5 metric tons (15 short tons) were propelled about 840 metres (2,800 feet), resulting in two deaths, 33 serious injuries, and destruction of 54 homes.

For a national perspective on the problem, figures from the Manufacturing Chemists Association (MCA) and the Federal Railroad Administration (FRA) are instructive. More than 10,000 manufacturers of hazardous materials annually ship some 1.8 billion metric tons (2 billion short tons) of product by various modes of transportation from 100,000 locations in the United States, according to an MCA estimate. The railroad tank car is one of the principal means of conveyance of such materials. FRA records indicate an average of 30 to 40 accidents each year marked by fires and explosions involving tank cars.

The accidents leave in their wake some shaken communities. At the same time, wrecked tank cars furnish evidence for technical analysts to sift through as new methods are sought for providing highly impact-resistant cars and improved safety systems.

FRA, the responsible agency in charge of the research program, has enlisted in this effort government scientists and engineers as well as industry experts from the Association of American Railroads and five major tank car builders acting through the Railway Progress Institute.

Not surprisingly, the National Bureau of Standards is an active participant in this program. Nearly 60 years ago, Dr. George K. Burgess—who was later to become the Bureau's second Director—authored a series of reports analyzing failures in defective rails, wheels, and axles. Burgess and the then-emerging NBS metallurgical unit helped American railroading to a more adequate understanding of crucial factors in the manufacture and use of the industry's iron and steel components. In the next decade, railroad accidents caused by defective materials decreased by more than two-thirds.

Today's tank car and hazardous materials problem is the focus of a similar effort and, once again, NBS is

Derailment at Docena, Ala. Remains of pressure tanks and other freight cars smolder over a wide swath of countryside. Local authorities hurriedly evacuated residents in fear of possible spread of poisonous gases.

Photo courtesy of National Fire Protection Association.

playing an important role in cooperation with the FRA's government/industry team of experts.

Working both with failure specimens from major accidents of recent years and with specimens from experimentally induced failures, NBS research findings are being used in the analysis of punctures and ruptures sustained by tank cars under various conditions of use and abuse. In particular, input from the Bureau's Mechanical Properties Section is helping FRA:

- Review and evaluate present specifications for fabrication of tank cars.
- Prepare guidelines and recommendations for potential candidate steels to replace currently specified steels.
- Evaluate elevated-temperature properties of existing or candidate tank-car steels.
- Metallurgically evaluate results of full-scale tank-car failure tests at the Army's White Sands Missile Range in New Mexico.

NBS reports to FRA concern such matters as whether or not steel plate samples taken from wrecked tank cars conformed to applicable specifications and, beyond this, the Bureau's judgment as to the suitability of the specified steels for carrying hazardous materials.

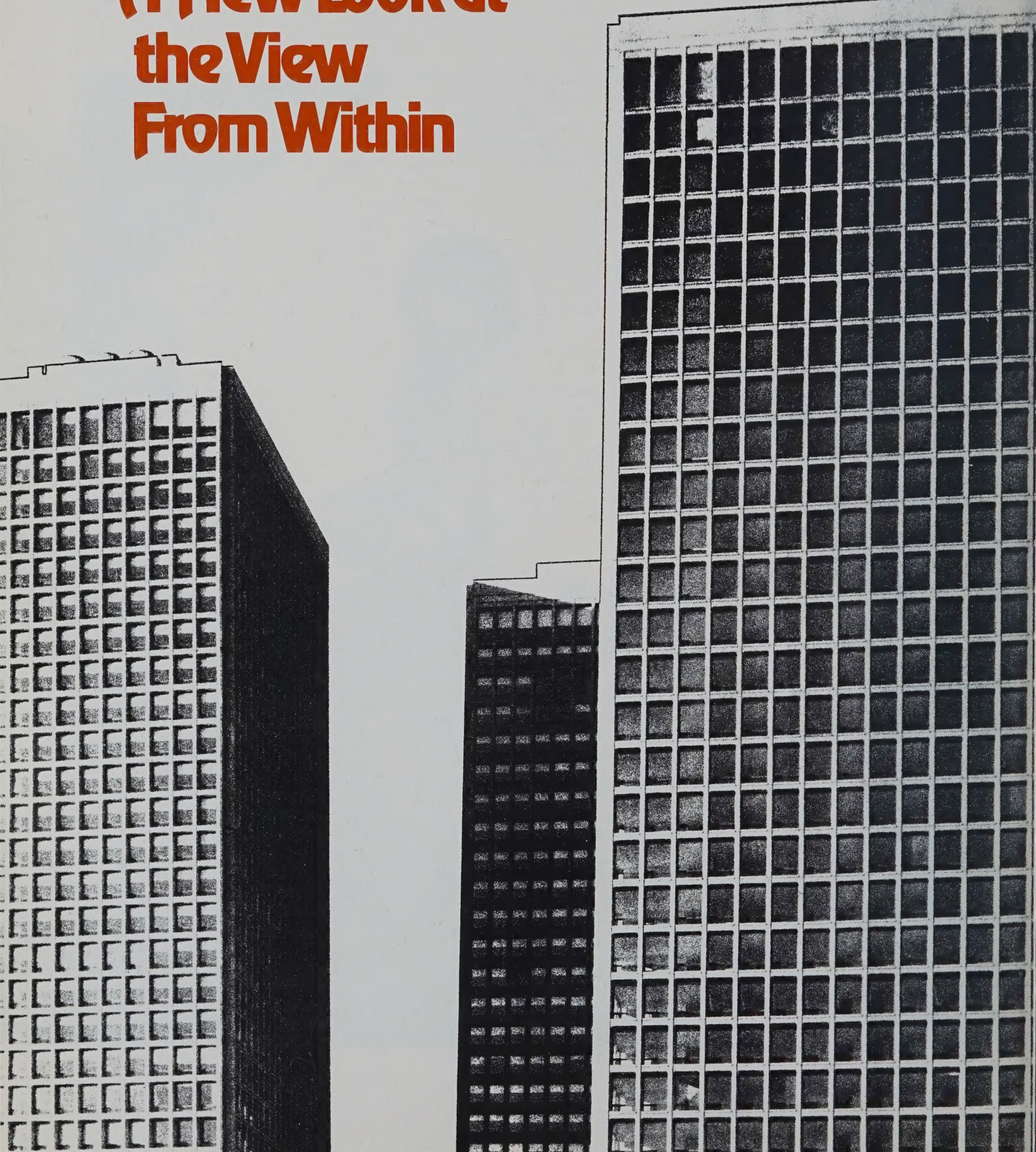
To provide a basis for FRA evaluation of the collective behavior of the steels, NBS reports focus on chemistry, mechanical properties such as tensile and impact properties, and microstructural and fracture surface observations. Both ambient-temperature and elevated-temperature properties are evaluated.

For example, a portion of shell plate recovered from a tank car that

continued on page 191

Drs. Charles G. Interrante (left) and James G. Early of NBS inspect a portion of the top of a 125,000-liter (33,000-gallon) tank car experimentally tested to failure in fire engulfment tests at the Army's White Sands Missile Range in New Mexico.

A New Look at the View From Within



HOW many times a day do you look out the window? Do you need that view to the outside?

Researchers at the National Bureau of Standards are spending a lot of time these days looking at windows—not out of them. As part of the NBS energy conservation studies, they are trying to determine whether energy-saving, windowless buildings are really a good idea.

Research psychologist Dr. Belinda Lowenhaupt Collins, of the Center for Building Technology, has examined existing research in the field and is beginning a series of original studies. She says that windows involve more than meets the eye.

"It seems clear that they afford a lot of pleasure and perform many other functions," she said. "Some people tend to forget that buildings are for people, not for mechanical systems."

But lately the window has been attacked by some people as an unnecessary frill. Conventional types of windows can lose heat in winter and gain heat in summer, increasing the energy costs of keeping a building comfortable. If you can heat, cool, ventilate, and illuminate a building mechanically, some people ask, why have windows?

There are a lot of reasons to have them, according to Collins' research to date. Windows not only provide a "view"—they also provide information. A window can tell you the weather, the time of day, and the activities of people around you.

Windows also provide momentary escape from static, confining situations. They give access to sunshine and daylight. They allow workers' eyes to rest by focusing on distant objects. In many offices, they even serve as status symbols for high-ranking personnel.

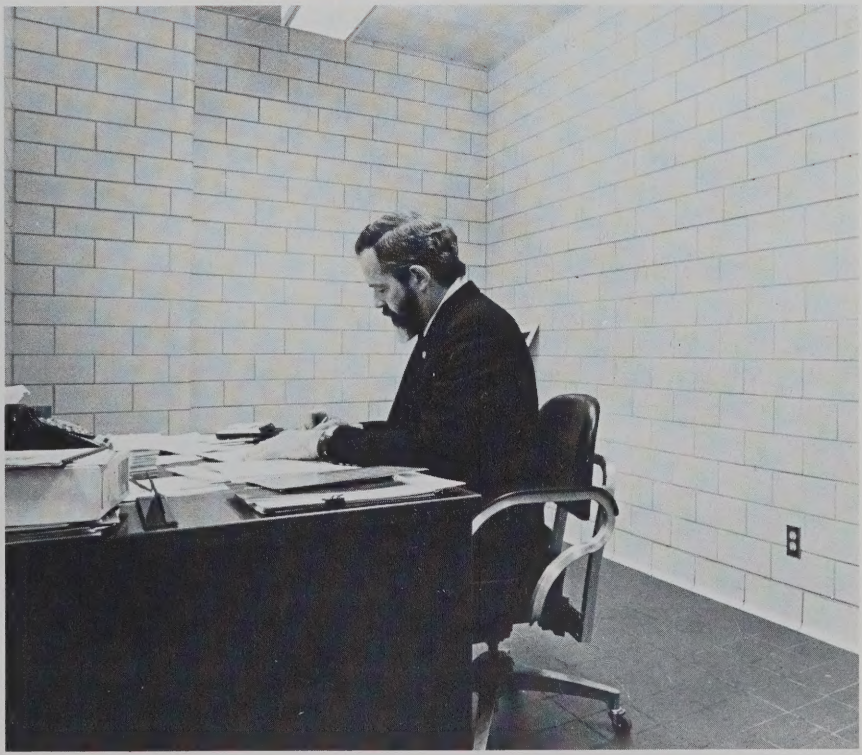
Reactions to windowless environments vary among individuals, and also depend on what's going on inside the walls. The kind of activity, the size of the space, the opportunity for personal interaction, and the number of occupants in a space are all factors that appear to influence attitudes towards windowless environments.

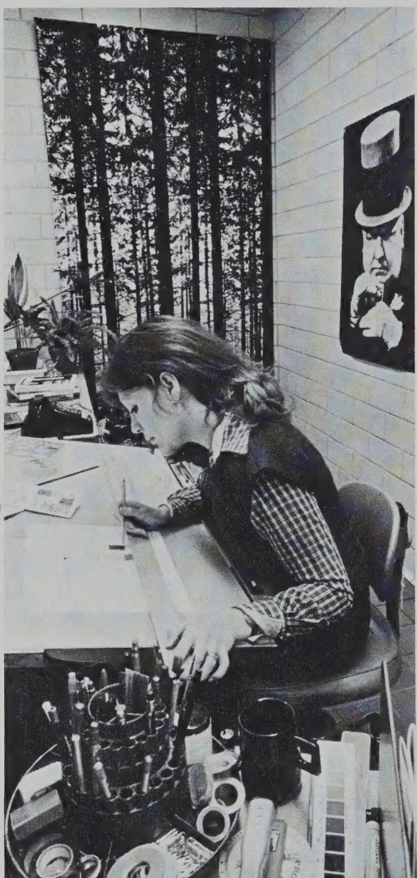
A study of more than 100 Seattle office workers revealed that despite general satisfaction with working conditions, 90 percent of the workers disliked the absence of windows in their offices. All were female clerical personnel who performed routing tasks in small one- or two-person offices. They complained about the lack of daylight, poor ventilation, and feelings of confinement, depression, and tension. They also expressed a desire to know the weather and to have a view out. Almost 50 percent thought the absence of a view affected them or their work adversely.

On the other hand, research has shown that the absence of windows is acceptable—or even preferable—in some places. Museums, theaters, restaurants, and department stores are rarely criticized for lacking them. The activity and excitement in these environments preclude the need for

turn page

Studies show that some people tolerate or even like windowless offices.





People in windowless offices sometimes compensate for the absence of a view, as with the poster of a forest scene shown above.

escape or distraction. In fact, extra light and glare could harm museum pieces or detract from the "atmosphere" of a darkened theater or candlelit restaurant.

In some places, though, the case for visual access to the outside is beyond debate. Hospital wards, for example, definitely need windows, according to studies. Physicians in Arkansas examined 100 surgical patients similar in age, sex, general physical condition, type of surgery, and treatment. Half the group was placed in a windowless intensive care unit following surgery, and the other fifty patients were in a unit with windows.

The physicians found that more than twice as many patients in the windowless unit developed post-operative delirium—a brief psychotic episode that is somewhat common after surgery but is nonetheless traumatic for the patient and difficult for the hospital staff. Furthermore, a greater number of other patients in the windowless ward developed post-operative depression and other adverse psychological reactions.

The researcher concluded that windowless hospital rooms further stress an already stressed patient and that windows help assure convalescents that they are still in the "real world."

Research dealing with windowless schools has not been as conclusive as the hospital research, Collins discovered. "In the early sixties a lot of windowless schools were built to be safe against nuclear attack," she said, "but now people claim that windowless schools are safer against vandalism."

It appears that college students, who spend only an hour or two in a classroom before moving to another location, can tolerate windowless classrooms better than younger pupils. Young children learning about the world around them could probably benefit from windows, Collins said. Nonetheless, some elementary school teachers have expressed a preference for the extra wall space and lack of distraction in windowless classrooms.

While people may be able to tolerate some types of windowless environments, it appears that very few would accept windowless homes. "There is a strong desire for both sunshine and daylight in the home," said Collins. "People want privacy from their neighbors, but they also want to know what's going on outside and what the weather is like."

People also like to have a "view," preferably a pleasing one, especially at home. A "good view," however, is not just a pretty one, but one that provides information, according to research to date. An informative view includes a look at the ground, the horizon, and the sky. If action and changes are visible through the window, the view is considered even more preferable.

Lighting is another environmental factor that people care about. A 1965 study found that people consider daylight the best illuminant, even if plenty of artificial light is available. "We really ought to look into the economic benefits of using daylight as part of office lighting," Collins added.

One factor that isn't often mentioned is safety. What if a fire occurs? Without windows that can be used as emergency escape routes, sophisticated safety features would be necessary even in low-rise buildings.

Studies have shown that people in windowless offices sometimes surround their desks with plants, pic-

tures of outdoor scenes, and other symbols of the windows they miss. However, other people tolerate or even like windowless offices. "It's clear that personality and other similar variables are involved," Collins said.

Objectively evaluating the positive or negative effects of windowless environments can definitely be difficult, Collins noted. "It's possible that windowless offices could induce greater absenteeism, more trips outside the buildings, or lower productivity, but we haven't yet been able to measure those things effectively," she said. "You can only measure productivity in the most routine jobs, and even then a lot of other factors enter the picture."

These difficulties, as well as the inconclusiveness of some of the studies, simply point to a need for further research, Collins stated. "There's a real lack of research in this field," she noted. "People have studied specific aspects of windows such as view or daylight, but very few studies have examined the overall impact of windows."

Furthermore, she noted, most of the research on windows has been conducted in England and northern Europe rather than in the United States. "It's possible that cultural and climatic differences between our country and theirs could make a difference," she said. Sunshine is probably valued more highly in northern Europe than in some parts of the U.S., and there may be different cultural attitudes regarding privacy.

"The British and Europeans have well-established building research programs," Collins commented, "and they emphasize the human factor, which we tend to ignore. The whole reason for our research is the fact that the human element has been overlooked—the needs of people haven't been considered."

Collins pointed out that there are ways to save energy and keep windows as well. Reduced window size, better insulation, double and triple glazing, and special solar glass can all help reduce wasted energy.

"It seems clear that there is no single solution for reducing the energy that windows use, because we have not yet fully specified human requirements," Collins said. "However, it is also clear that windows do perform desirable functions for people, and they should not be overlooked in designing energy-efficient buildings." □

This basement dweller in the Washington, D.C. area has transcended his windowless environment with a curtained "view" of the Rockies.

NBS Brightens the Way for Highway Safety

ONE of the most frightening aspects of modern-day driving is groping along an unfamiliar road on a rainy night. "The lack of lane guidance at night in rain remains one of the most critical of highway safety problems," states the Federal Highway Administration (FHWA). The problem has been solved in southern states by supplementing conventional painted stripes with raised reflective markers. In northern states, however, snowplows damage the raised markers and they cannot be used. At the present time, FHWA is trying to modify these markers to make them resistant to snowplow damage.

They are also exploring other possibilities and have found some indication of success with electrically lighted lane markers recessed in the roadway. These snowplow-proof markers concentrate the light from a low-power lamp into a narrow, nearly horizontal beam directed at approaching drivers.

James M. Kenney sets up transducer at edge of heavily traveled highway.

The markers are connected by a transformer to commercial power lines and they operate continuously during the nighttime hours. Because of the tremendous amount of energy that this system uses, FHWA is interested in developing an alternative method that lights the markers only when traffic is approaching.

They have turned to the National Bureau of Standards to test the technical feasibility of one such system. It is a modern-day adaptation of the Indian practice of putting an ear to the ground to detect—by the vibration of the earth—the presence of horses that are too far away to be seen. The modern version is to attach piezoelectric sensors to the roadway to detect the pavement-borne sound from approaching vehicles. The sensor is typically the size and shape of a half dollar and has electrodes attached to the opposite surfaces. It is piezoelectric because mechanical deformation of the sensor, caused by vibration, produces a voltage across the electrodes. A metal seismic mass of the same diameter is sometimes placed over the sensor to increase its sensitivity to vibration.

Kenney places aluminum foil around a pre-amplifier to keep it cool in the hot sun.

No traffic-sensitive electrical marker system has been constructed prior to this time. NBS, and more specifically James M. Kenney of the Polymers Division, has been conducting road vibration measurements to determine if such a system is technically feasible. "From my preliminary measurements it looks as though it will work," says Kenney. His final report will be delivered to FHWA in November.

Kenney believes a polymer sensor he has been testing will be the most practical device. It would cost only pennies to produce in quantity. A car could run over it without breaking it. "And it should be easier to put down on the roadway," Kenney says.

Kenney attaches cord from transducer to tape recorder.

Under guidelines established by the FHWA, the triggering signal from the sensor circuit must activate the warning light when a vehicle weighing about 900 kilograms (2,000 pounds) or more approaches at a speed of about 50 kilometres (30 miles) per hour or faster and is no closer than 25 metres (82 feet) to the marker.

For the past several months Kenney has been traveling the highways of Maryland to field test sensors on a variety of road surfaces. He plasters the transducer to the roadway and then records on tape the very-low-frequency noise vibration in the roadway caused by vehicles approaching the sensor at distances greater than about 30 metres (100 feet).

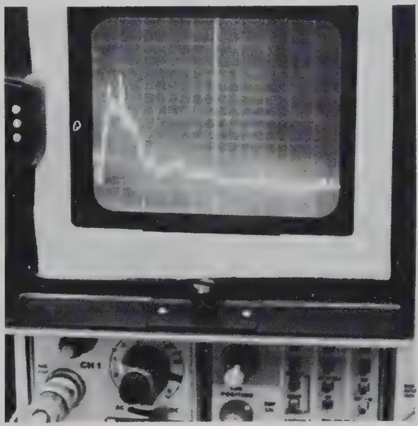
First he had to determine the frequency spectra of vibration noise that traffic makes, then he had to select a sensor that will pick up this noise under the FHWA guidelines. Kenney is now developing a baseline for this noise that would be applicable for various types of road surface and traffic patterns.

To hear the playback of his tapes (raised in frequency 10 times) is like listening to static on the radio or sounds that Kenney relates to "the bombardment of Fort McHenry."

Although he often spent 4 and 5 hours a day just off the shoulders of some of the nation's more heavily traveled highways, Kenney said the only really dangerous part of his project, aside from dehydration in the hot sun, was attaching the transducer to the roadway while traffic whizzed past him. To protect himself—and his equipment—he borrowed traffic cones from the NBS security force and placed them around his work area. No one other than an occasional curious policeman ever stopped to ask him what he was doing.

One interesting offshoot of his work was the discovery of significant roadway background vibrations in the absence of nearby traffic. As there is more and more residential and commercial construction along the nation's super highways, Kenney believes that long-distance vibrations will become an important environmental consideration. Persons wishing to build along major highways and railways may wish to measure the vibration level first to determine if it would have any deleterious effect on structures or individuals. This may become an important type of environmental pollution measurement, Kenney thinks. □

He sits in his car recording the sounds of on-coming traffic.



Back in the laboratory, the recordings are translated into blips on an oscilloscope.

Kenney, using oscilloscope, begins to analyze data.

Making the Most of Your Energy Dollars

CAN I afford to add storm windows and more insulation to my home? With the soaring price of energy, can I afford not to? The dollar conscious homeowner who asks these questions now has a way of figuring the dollar sense of making—or not making—these and other energy conserving improvements.

The National Bureau of Standards and the Federal Energy Administration have published a consumer guide that allows the homeowner to figure out the best combination of improvements for the largest long-run return on an investment. By using this guide, called "Making the Most of Your Energy Dollars in Home Heating and Cooling," the homeowner can determine how much to invest, and he can get information on financing and tips on making the improvements.

Part of the booklet is reprinted on the following pages. The reprint explains how to figure an energy conservation budget. The complete booklet is available for 70 cents through the Superintendent of Documents, U.S. Printing Office, Washington, D.C. 20402. Order by SD Catalog No. C13.53:8. □

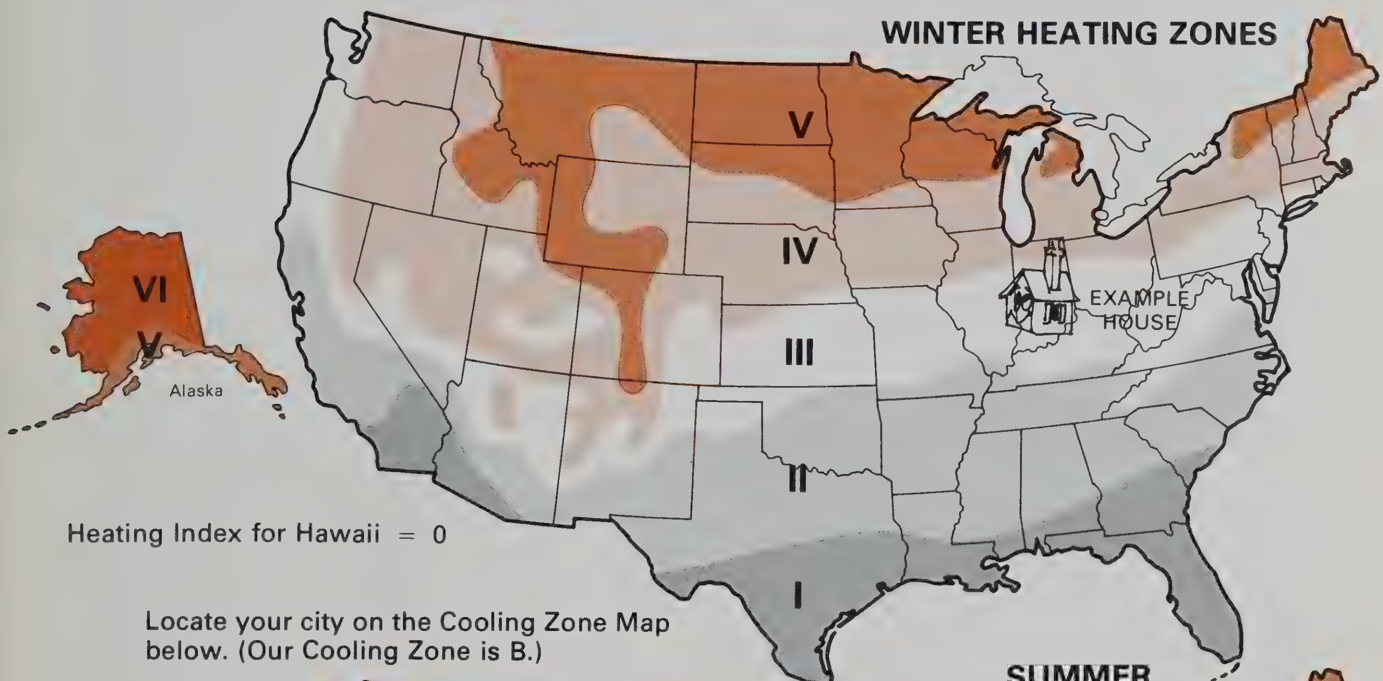
FIGURING YOUR ENERGY CONSERVATION BUDGET

To find the "best combination" of energy conservation measures for your climate and fuel prices, use the tables on the following pages. This best combination gives you the largest, long run net savings on your heating and cooling costs for your investment. By comparing this best combination with what already exists in your house, you can figure out how much more needs to be added to bring your house up to the recommended levels.

The recommended improvements apply to most houses to the extent they can be installed without structurally modifying the house. Recommended improvements are based on sample costs given in Table 7.

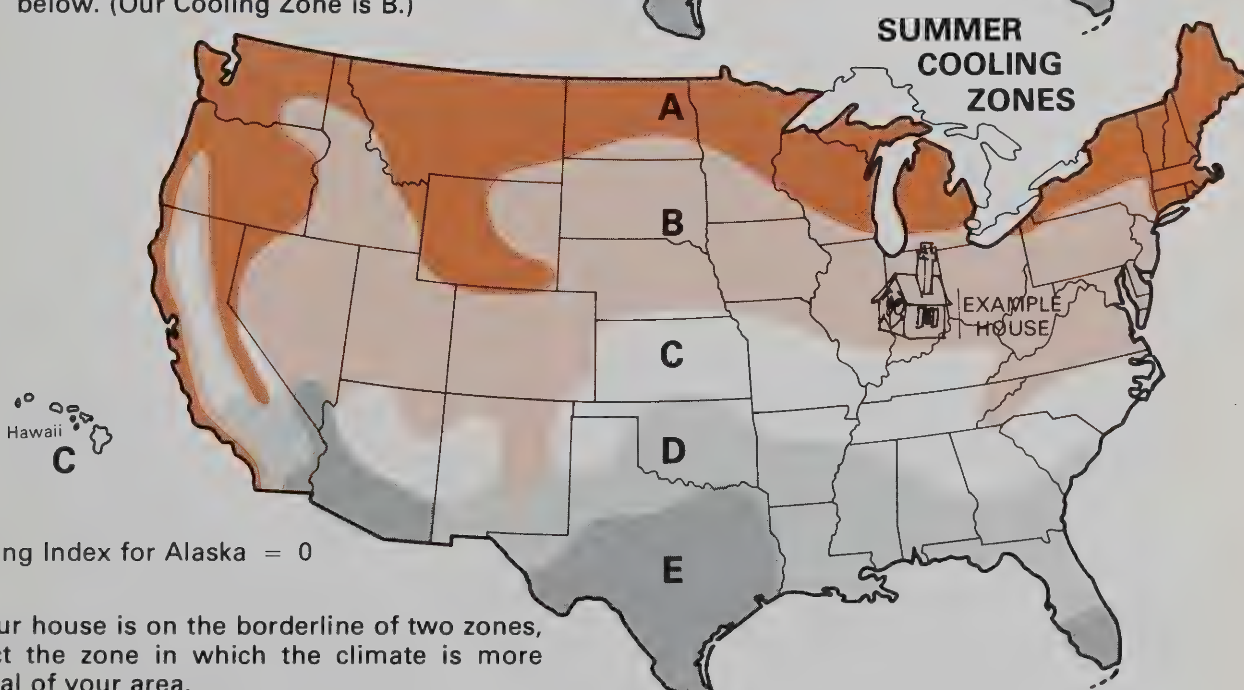
Follow the steps outlined below and fill in the information for your house on Worksheet A. We have filled in the information for a typical house located in Indianapolis, Indiana.

Locate your city on the Heating Zone Map below. (Our house is located in Heating Zone III.)



Heating Index for Hawaii = 0

Locate your city on the Cooling Zone Map below. (Our Cooling Zone is B.)



Cooling Index for Alaska = 0

If your house is on the borderline of two zones, select the zone in which the climate is more typical of your area.

3 Our house currently uses fuel oil at a cost of 34¢ a gallon to heat. It uses electricity at 4¢ a kilowatt hour to cool. Obtain your unit heating and cooling costs from the utility companies as follows: Tell your company how many therms (for gas) or kilowatt hours (for electricity) you use in a typical winter month and summer month (if you have air conditioning). The number of therms or kilowatt hours is on your monthly fuel bill. Ask for the cost of the last therm or kilowatt hour used, including all taxes, surcharges, and fuel adjustments. For oil heating, the unit fuel cost is simply your average cost per gallon plus taxes, surcharges, and fuel adjustments.

4 Locate your Heating Index from Table 1 by finding the number at the intersection of your Heating Zone row and heating fuel cost column (to the nearest cost shown). (Our house has a Heating Index of 20.)

If your house is air conditioned, or you plan to add air conditioning, find your Cooling Indexes from steps 5 and 6. If your house is not air conditioned and it is not planned, your Cooling Indexes are zero.

TABLE 1 HEATING INDEX

Type of fuel:	Cost per unit*									
Gas (therm)	9¢	12¢	15¢	18¢	24¢	30¢	36¢	54¢	72¢	90¢
Oil (gallon)	13¢	17¢	21¢	25¢	34¢	42¢	50¢	75¢	$1.00	$1.25
Electric (kWh)				1¢	1.3¢	1.6¢	2¢	3¢	4¢	5¢
Heat pump (kWh)	1¢	1.3¢	1.7¢	2¢	2.6¢	3.3¢	4¢	6¢	8¢	10¢
HEATING ZONE I	2	2	3	3	4	5	6	9	12	15
HEATING ZONE II	5	6	8	9	12	15	18	27	36	45
HEATING ZONE III	8	10	13	15	20	25	30	45	60	75
HEATING ZONE IV	11	14	18	21	28	35	42	63	84	105
HEATING ZONE V	14	18	23	27	36	45	54	81	108	135
HEATING ZONE VI	22	28	36	42	56	70	84	126	168	210

Note: In Tables 1-3, if your fuel costs fall midway between two fuel costs listed, you can interpolate. For example, if our fuel oil costs were 38¢ a gallon, our Heating Index would be 22.5.

5 Locate your Cooling Index for Attics from Table 2 by finding your Cooling Zone and cooling cost to the nearest cost shown. (Our house has a Cooling Index for Attics of 5.)

6 Locate your Cooling Index for Walls from Table 3 by finding your Cooling Zone and cooling cost to the nearest cost shown in the table. (Our house has a Cooling Index for Walls of 2.)

TABLE 2 COOLING INDEX FOR ATTICS

Type of air conditioner:	Cost per unit*						
Gas (therm)	9¢	12¢	15¢	18¢	24¢	30¢	36¢
Electric (kWh)	1.5¢	2¢	2.5¢	3¢	4¢	5¢	6¢
COOLING ZONE A	0	0	0	0	0	0	0
COOLING ZONE B	2	2	3	4	5	6	7
COOLING ZONE C	3	5	6	7	9	11	13
COOLING ZONE D	5	6	8	9	12	15	18
COOLING ZONE E	7	9	11	14	18	23	27

TABLE 3 COOLING INDEX FOR WALLS

Type of air conditioner:	Cost per unit*						
Gas (therm)	9¢	12¢	15¢	18¢	24¢	30¢	36¢
Electric (kWh)	1.5¢	2¢	2.5¢	3¢	4¢	5¢	6¢
COOLING ZONE A	0	0	0	0	0	0	0
COOLING ZONE B	1	1	2	2	2	3	4
COOLING ZONE C	2	2	3	4	5	6	7
COOLING ZONE D	3	3	4	5	7	8	10
COOLING ZONE E	4	5	6	8	10	13	15

*Cost of last unit used (for heating and cooling purposes) including all taxes, surcharges, and fuel adjustments.

7 Find the sum of your Heating Index and Cooling Index for Attics. (Our sum is 25.)

8 Find the sum of your Heating Index and Cooling Index for Walls. (Our sum is 22.)

Energy savings result from decreasing the heat flow through the exterior shell of the building. The resistance, or "R," value of insulation is the measure of its ability to decrease heat flow. Two different kinds of insulation may have the same thickness, but the one with the higher R value will perform better. For that reason, our recommendations are listed in terms of R values with the approximate corresponding thickness. R values for different thicknesses of insulation are generally made available by the manufacturers.

9 Find the resistance value of insulation recommended for your attic and around attic ducts from Table 4. (For our house the recommended resistance value is R-30 for attic floors and R-16 for ducts.)

TABLE 4 ATTIC FLOOR INSULATION AND ATTIC DUCT INSULATION

INDEX Heating Index Plus Cooling Index for Attics	ATTIC INSULATION R-Value	Approximate Thickness: Mineral Fiber Batt/Blanket	Mineral Fiber Loose-Fill**	Cellulose Loose-Fill**	DUCT INSULATION* R-Value	Approximate Thickness
1-3	R-0	0"	0"	0"	R-8	2"
4-9	R-11	4"	4-6"	2- 4"	R-8	2"
10-15	R-19	6"	8-10"	4- 6"	R-8	2"
16-27	R-30***	10"	13-15"	7- 9"	R-16	4"
28-35	R-33	11"	14-16"	8-10"	R-16	4"
36-45	R-38	12"	17-19"	9-11"	R-24	6"
46-60	R-44	14"	19-21"	11-13"	R-24	6"
61-85	R-49	16"	22-24"	12-14"	R-32	8"
86-105	R-57	18"	25-27"	14-16"	R-32	8"
106-130	R-60	19"	27-29"	15-17"	R-32	8"
131—	R-66	21"	29-31"	17-19"	R-40	10"

* Use Heating Index only if ducts are not used for air conditioning. ** High levels of loose-fill insulation may not be feasible in many attics. ***Assumes that joists are covered; otherwise use R-22.

10 Find the recommended level of insulation for floors over unheated areas from Table 5. (Our house should have R-19.) Using Table 5, check to see whether storm doors are economical for your home. Storm doors listed as optional may be economical if the doorway is heavily used during the heating season.

11 Find the recommended level of insulation for your walls and ducts in unheated areas from Table 6. (Our house should have full-wall insulation if none existed previously and R-16 insulation around ducts.) Table 6 also shows the minimum economical storm window size in square feet for triple-track storm windows. (Our house should have storm windows on all windows 9 square feet in size or larger where storm windows can be used.)

TABLE 5 INSULATION UNDER FLOORS AND STORM DOORS

INDEX Heating Index Only	INSULATION UNDER FLOORS* R-Value	Mineral Fiber Batt Thickness	STORM DOORS
0-7	0**	0"**	None
8-15	11**	4"**	None
16-30	19	6"	Optional
31-65	22	7"	Optional
66—	22	7"	On all doors

* If your furnace and hot water heater are located in an otherwise unheated basement, cut your Heating Index in half to find the level of floor insulation.
**In Zone I and II R-11 insulation is usually economical under floors over open crawlspaces and over garages; in Zone I insulation is not usually economical if crawlspace is closed off.

TABLE 6 WALL INSULATION, DUCT INSULATION, AND STORM WINDOWS

INDEX Heating Index Plus Cooling Index for Walls	WALL INSULATION (blown-in)	INSULATION AROUND DUCTS IN CRAWLSPACES AND IN OTHER UNHEATED AREAS (EXCEPT ATTICS)* Resistance and Approximate Thickness	STORM WINDOWS (Triple-Track) Minimum Economical Window Size
0-10	None	R-8 (2")	none
11-12	Full-Wall Insulation Approximately R-14	R-8 (2")	20 sq. ft.
13-15		R-16(4")	15 sq. ft.
16-19		R-16(4")	12 sq. ft.
20-28		R-16(4")	9 sq. ft.
29-35		R-16(4")	6 sq. ft.
36-45		R-24(6")	4 sq. ft.
46-65		R-24(6")	All windows**
66—		R-32(8")	All windows**

* Use Heating Index only if ducts are not used for air conditioning. **Windows too small for triple-track windows can be fitted with one-piece windows.

12 Weather stripping and caulking.
Regardless of where you live or your cost of energy, it is almost always economical to install weather stripping on the inside around doors and windows where possible and to caulk on the outside around doors and window frames—if you do it yourself. This is especially true for windows and doors which have noticeable drafts.

YOU NOW KNOW your best combination of energy conservation improvements. Of course, the size of your investment depends on your existing insulation and the size of your house.

In addition, some of the recommended improvements in this booklet are not appropriate for all houses. For instance, insulation cannot be added under floors in houses built on concrete slabs. In such cases, the other recommended improvements should still be added to the extent indicated in this booklet. Similarly, R-30 insulation may be recommended for your attic although only R-19 may fit at the eaves or in areas where the attic is floored. In this case, you should still put R-30 insulation wherever it fits.

Use Worksheet B and Table 7 (or your own cost information) to calculate how much you need to add to reach your best combination and how much this will cost. We have provided this information on Worksheet B for our example house. Our house only has R-11 attic insulation, some wall insulation, and R-8 attic duct insulation to begin with. To reach our best combination, the improvements would cost about $1200.

WORKSHEET A

EXAMPLE:

Climate:	
Heating Zone	III
Cooling Zone	B
Fuel Costs:	
Heating Energy	Oil
Cost per Unit	34¢/gal.
Cooling Energy	Electric
Cost per Unit	4¢/KWH
Indexes:	
Heating	20
Cooling (Attic)	5
Cooling (Wall)	2
Heating + Cooling (Attic)	25
Heating + Cooling (Wall)	22

BEST COMBINATION

Attic Insulation (Batt)	R-30 (10 inches)	FROM TABLE 4
Duct Insulation (in attics)	R-16 (4 inches)	FROM TABLE 4
Insulation Under Floors	R-19 (6 inches)	FROM TABLE 5
Storm Doors	optional	FROM TABLE 5
Wall Insulation (blown-in)	full-wall R-14 (3½ inches)	FROM TABLE 6
Duct Insulation (in unheated crawl-spaces, etc.)	R-16 (4 inches)	FROM TABLE 6
Storm Windows (minimum size)	9 sq. ft.	FROM TABLE 6
Weather strip and caulk windows and door frames	all	

YOUR CALCULATIONS:

Climate:	
Heating Zone	
Cooling Zone	
Fuel Costs:	
Heating Energy	
Cost per Unit	
Cooling Energy	
Cost per Unit	
Indexes:	
Heating	
Cooling (Attic)	
Cooling (Wall)	
Heating + Cooling (Attic)	
Heating + Cooling (Wall)	

BEST COMBINATION

Attic Insulation	
Duct Insulation (in attics)	
Insulation Under Floors	
Storm Doors	
Wall Insulation (blown-in)	
Duct Insulation (in unheated crawlspaces, etc.)	
Storm Windows (minimum size)	
Weather strip and caulk windows and door frames	

WORKSHEET B

OUR EXAMPLE:

ATTIC INSULATION

1. Attic area (sq. ft.)	1200
2. Recommended level	R-30 (10")
3. Existing level	R-11 (4")
4. Add	R-19 (6")
5. Cost/sq. ft.	$.25
6. Total cost (1×5)	$300

WALL INSULATION (BLOWN-IN)

1. Wall area (sq. ft.)	900
2. Recommended level	full-wall
3. Existing level	some
4. Add	0
5. Cost/sq. ft.	$.60
6. Total cost (1×5)	0

FLOOR INSULATION

1. Floor area (sq. ft.)	1200
2. Recommended level	R-19 (6")
3. Existing level	0"
4. Add	R-19 (6")
5. Cost/sq. ft.	$.30
6. Total cost (1×5)	$360

DUCT INSULATION (ATTIC)

1. Length (ft.)	30'
2. Perimeter (ft.)	2'
3. Area (1×2×1.5)*	90 sq. ft.
4. Recommended level	R-16 (4")
5. Existing level	R-8 (2")
6. Add	R-8 (2")
7. Cost/sq. ft.	$.30
8. Total cost (3×7)	$27

DUCT INSULATION (OTHER AREAS)

1. Length (ft.)	30'
2. Perimeter (ft.)	2'
3. Area (1×2×1.5)*	90 sq. ft.
4. Recommended level	R-16 (4")
5. Existing level	0"
6. Add	R-16 (4")
7. Cost/sq. ft.	$.50
8. Total cost (3×7)	$45

STORM WINDOWS (over 9 sq. ft.)

size (sq. ft.)	number	cost each	sub-total
20	2	$35	$ 70
15	4	30	120
12	3	30	90
9	2	30	60

Total cost $340

STORM DOORS

1. Doors Needed	1 (Optional)
2. Cost per door	$75
3. Total cost	$75

WEATHER STRIPPING (MATERIALS ONLY)

1. Linear feet	200
2. Cost per foot	$.10
3. Total cost	$20

CAULKING (MATERIALS ONLY)

1. Variable costs	$20-50
2. Estimated cost	$33

Total cost of all improvements $1200

YOUR ESTIMATES:

ATTIC INSULATION

1. Attic area (sq. ft.) ______
2. Recommended level ______
3. Existing level ______
4. Add ______
5. Cost/sq. ft. ______
6. Total cost (1×5) ______

WALL INSULATION (BLOWN-IN)

1. Wall area (sq. ft.) ______
2. Recommended level ______
3. Existing level ______
4. Add ______
5. Cost/sq. ft. ______
6. Total cost (1×5) ______

FLOOR INSULATION

1. Floor area (sq. ft.) ______
2. Recommended level ______
3. Existing level ______
4. Add ______
5. Cost/sq. ft. ______
6. Total cost (1×5) ______

DUCT INSULATION (ATTIC)

1. Length (ft.) ______
2. Perimeter (ft.) ______
3. Area (1×2×1.5)* ______
4. Recommended level ______
5. Existing level ______
6. Add ______
7. Cost/sq. ft. ______
8. Total cost (3×7) ______

DUCT INSULATION (OTHER AREAS)

1. Length (ft.) ______
2. Perimeter (ft.) ______
3. Area (1×2×1.5)* ______
4. Recommended level ______
5. Existing level ______
6. Add ______
7. Cost/sq. ft. ______
8. Total cost (3×7) ______

STORM WINDOWS

size (sq. ft.)	number	cost each	sub-total

Total cost ______

STORM DOORS

1. Doors needed ______
2. Cost per door ______
3. Total cost ______

WEATHER STRIPPING (MATERIALS ONLY)

1. Linear feet ______
2. Cost per foot ______
3. Total cost ______

CAULKING (MATERIALS ONLY)

1. Variable costs ______
2. Estimated cost ______

Total cost of all improvements ______

*1.5 is an adjustment factor for increased width of insulation needed to fit around duct.

TABLE 7 SAMPLE IMPROVEMENT COSTS

These sample costs were used in estimating the best combination of energy conservation improvements for the various climates and fuel prices covered in this booklet. They include an allowance for commercial installation, except in the case of weather stripping and caulking which is considered to be a do-it-yourself project. While these costs are typical of 1975 prices, there may be considerable variation among specific materials, geographic locations, and suppliers. It usually is worth your time to obtain several estimates for materials and installation before making any purchase. Many of these items can be purchased at substantial discounts if you watch the advertised sales. Considerable savings may be made by installing these yourself, where possible.

ATTIC INSULATION (ALL MATERIALS)

Installed cost per square foot of attic:

R-11 = 15¢	R-44 = 57¢
R-19 = 25¢	R-49 = 64¢
R-22 = 29¢	R-57 = 74¢
R-30 = 39¢	R-60 = 78¢
R-33 = 43¢	R-66 = 86¢

WALL INSULATION (ALL MATERIALS)

Installed cost = 60¢ per square foot of net wall area*

FLOOR INSULATION (MINERAL FIBER BATT)

Installed cost:

R-11 = 20¢
R-19 = 30¢
R-22 = 34¢

DUCT INSULATION (MINERAL FIBER BLANKET)

Installed cost per square foot of material:

R-8 = 30¢	R-32 = 90¢
R-16 = 50¢	R-40 = $1.10
R-24 = 70¢	

STORM WINDOWS (TRIPLE-TRACK, CUSTOM-MADE AND INSTALLED**)

Up to 100 united inches (height+ width)	= $30.00
Greater than 100 united inches	= $30.00+ $.60 per united inch greater than 100"

STORM DOORS (CUSTOM-FITTED AND INSTALLED**)

All sizes = $75.00

WEATHER STRIPPING AND CAULKING

Prices vary according to material used. Use the most durable materials available.

* Price includes allowance for painting inside surface of exterior walls with water vapor-resistant paint.

**Prices may be considerably less for stock sizes, homeowner-installed.

If you find that the costs of any of the improvements to your house are substantially different from the sample costs in Table 7, you can easily compensate for the difference.

Take the Index Number appropriate for the improvement in question, multiply this by our sample cost, and divide the result by your cost. This will give you an Adjusted Index Number with which you can find the best level of investment for that particular improvement.

$$\frac{\text{Original Index} \times \text{Our Cost}}{\text{Your Cost}} = \text{Adjusted Index}$$

EXAMPLE

For our example house, we might find that we can get good quality storm windows for $20 apiece instead of our $30 estimate. Our Index Number for storm windows was 22. Our new Adjusted Index Number for storm windows would be: $\frac{22 \times \$30}{\$20} = 33$

Using our Adjusted Index Number of 33 we find that storm windows are economical on all windows 6 square feet in size or larger, instead of 9 square feet in size. In other words, if your costs are substantially less than ours, you will want to go beyond the recommended level.

Similarly, if R-30 insulation in the attic costs 65¢ per square foot instead of our 39¢ price, the Index Number of 25 for attic insulation would be adjusted to $\frac{25 \times 39¢}{65¢} = 15$

From Table 4 we find that R-19 insulation is now recommended instead of R-30. In other words, if your costs are substantially greater than ours, you may want to use a little less than the recommended level.

HIGHLIGHTS

High Wind Film

A 15-minute film has recently been released summarizing the initial results of an ongoing program on building structure and extreme winds. The 3-year project, sponsored by NBS and the Agency for International Development, is aimed at helping developing countries upgrade their low-rise buildings to better resist high winds. The film is available on free loan from: Association Sterling Films, 600 Grand Avenue, Ridgefield, N.H. 07657. For purchasing information write: Ron Meininger, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

Neutron Radiography Program

The initial problems in preparing three-dimensional thermal neutron radiographic images will be explored in a collaborative effort involving Argonne National Laboratory and NBS.

Problems to be explored include those involved in using a stationary radiation source, thereby forcing movement of object and detector, and those associated with film marker methods so films can be properly aligned after they are prepared. The neutron radiographic study is part of the NBS program in nondestructive evaluation.

New Glass SRM Issued

A new Standard Reference Material of major importance to the glass industry is now available. The glass composition standard, SRM 621, Soda Lime Glass, Container, supplements SRM 620, Soda Lime Glass, Flat (issued earlier). SRM 621 is provided in solid form (disks) and is intended for use both in checking chemical methods of analysis and in calibrating optical emission and X-ray spectrometric methods analysis. Order from Office of Standard Reference Materials, B314 Chemistry Building, NBS, Washington, D.C. 20234.

Booklets on Major Issues

Two new booklets concerning major issues of the day—energy conservation and metric conversion—are now available free of charge from the Office of Information Activities at NBS. "Energy Conservation Programs at the National Bureau of Standards" summarizes Bureau activities in energy conservation in building design and operation, appliance efficiency, evaluation of solar systems, and industrial energy usage. It contains a list of publications that detail specific steps that can be taken by anyone to reduce energy consumption.

"America's Alternatives: The Metric Conversion" is the statement made by former Director Richard W. Roberts before the House Subcommittee on Science, Research and Technology concerning metric conversion. Roberts says that many segments of society are adopting metric measurement and he urges a coordinated approach to ensure that the change will be most efficient and least costly. The booklet also contains a list of publications on the U.S. Metric Study and other metric publications available from NBS, the American National Standards Institute, and other national organizations.

Biological Molecules Program

NBS and the National Institutes of Health have initiated a program in the study of the structure of biological molecules using neutron diffraction techniques. This important health-related research should provide detailed structural information on the hydrogen bonds and constituent water molecules in biological systems which play an important role in biochemical and life processes.

Consumer Sounding-Boards

Five national standards-making organizations, including NBS, are cooperating to sponsor and promote Consumer Sounding Boards. These Boards are being established throughout the country to involve consumers in the development of voluntary standards for a variety of products. The first meeting of a Washington-area Consumer Sounding Board took place in May 1975 at NBS. The group commented on three proposed labels for laundry equipment being developed by NBS as part of the appliance labeling program. NBS staff will consider the comments in preparing final labels.

Data Elements Symposium

The Second National Symposium on the Management of Data Elements in Information Processing will be held at NBS in Gaithersburg, Md., October 23-24, 1975. The symposium is sponsored by NBS and the American National Standards Institute. It will include presentations on timely data management and data standardization topics such as: the role of the data manager, communications needs for data standards, data element directories, standard codes for character and control, and coding for clinical medicine.

Registration is $50, in advance. Contact: Hazel McEwen, ICST, NBS, Washington, D.C. 20234, phone 301/921-3157. □

Surface Analysis for Silicon Devices

A workshop held at the National Bureau of Standards earlier this year focused on particle and beam techniques useful to the semiconductor industry in determining impurity profiles, surface contamination, and interface characteristics of silicon devices. Highlighting the workshop were three approaches to overcoming the problem of sodium migration during distribution profiling measurements and debates about the existence and extent of the nonstoichiometric transition region at the silicon dioxide-silicon interface.

Sponsored by NBS and the Defense Advanced Research Projects Agency (ARPA), the meeting was the fourth in a series of ARPA/NBS workshops concerned with measurement problems in integrated circuit processing and assembly.

Beam probe techniques offer a range of elemental detection sensitivities and spatial and molecular weight resolutions that invite exploitation in the analysis of silicon and associated insular films and device structures. Furthermore, these techniques are able to detect electrically inactive impurities as well as active ones. This capability is important in measuring and controlling impurities that become electrically active and contribute to device degradation after radiation exposure. A case in point is the detection of sodium atoms in the oxides of MOS devices.

The detection and measurement of depth-resolved concentration profiles of sodium ions in silicon dioxide films by various techniques were discussed by a number of speakers at the workshop. One of the problems with the measurement of mobile impurities such as sodium is impurity migration due to charge interactions with the beam probe. B. F. Phillips (Naval Ammunition Depot, Crane, Ind.) presented data showing that cooling the sample to cryogenic temperatures (−180°C) retarded such migration during analysis in a secondary ion mass spectrometer (SIMS). Dr. R. D. Dobrott (Texas Instruments, Inc., Dallas, Tex.) suggested an alternative approach by which secondary electron emission from a metal grid is used to neutralize the insulator charging effects responsible for inducing sodium ion migration during ion bombardment.

Ion migration can also be reduced during analysis by replacing the ion beam with a neutral particle beam and observing the optical emission rather than the sputtered ion mass. This is what is done in the SCANIIR technique described by Dr. C. W. White (Bell Telephone Laboratories, Allentown, Pa.).

The detection of sodium by X-ray photoelectron spectroscopy (also known as ESCA) at concentration levels as low as 10^{10} cm^{-2} SiO_2 and the ability to distinguish between mobile and bound sodium by this technique were reported by Dr. F. J. Brunthaner (Jet Propulsion Laboratory, Pasadena, Calif.).

The existence and extent of a nonstoichiometric transition region in the SiO_2 film near the silicon substrate was a subject of considerable interest. The lack of stoichiometry was revealed by a novel Auger electron study of the chemical coordination in thermally oxidized silicon by Dr. Jan S. Johansessen (Stanford Electronics Laboratories, Stanford, Calif.) and Y. E. Strausser (Varian Associates, Palo Alto, Calif.). Using low energy ion scattering spectroscopy, this transition was shown to extend over many tens of Angstroms by Dr. W. L. Harrington (RCA Laboratories, Princeton, N.J.).

The detection limits and the capability for making quantitative determinations by beam probe techniques was another area of active discussion by speakers and participants. Dr. C. A. Evans, Jr. (University of Illinois, Urbana, Ill.) pointed out that no single beam spectroscopy can provide all the answers and that before these beam techniques can be used to provide reliable and quantitative determinations, standard reference materials and standard measurement procedures must be developed.

Both Evans and Dr. K. L. Dunning (Naval Research Laboratory, Washington, D.C.) pointed out that the Rutherford backscattering and the protonresonance techniques can provide essentially nondestructive quantitative measurements of impurity profiles, accurate to within 5 percent, for use in the development of standard reference materials for calibrating other surface instrumentation.

The collection of 25 papers presented at this ARPA/NBS workshop is being prepared for publication. Additional information concerning the workshop may be obtained by contacting the workshop chairman, Dr.

A. G. Lieberman (telephone: 301/921-3625), Technology Building, Room B346, NBS, Washington, D.C. 20234.

The NBS work on the analysis of silicon, and of silicon surfaces and interfaces, is part of an ARPA-sponsored activity titled "Advancement of Reliability, Processing and Automation for Integrated Circuits with the National Bureau of Standards." This activity is a major element of the NBS Semiconductor Technology Program which seeks to develop, and to disseminate to the electronics community, carefully evaluated and well-documented test procedures and associated technology to solve measurement and standardization problems in connection with the manufacture, procurement, and application of semiconductor devices. □

Energy-Efficient Water Heaters to Save Money

LIKE the wise homeowner who examines ways to reduce consumption when the monthly utility bill arrives, the Federal Government is screening its purchases carefully to obtain maximum energy conservation.

The most recent example is the purchase of 7,700 gas and electric home hot water heaters that use 11 percent less energy and are expected to save the government $300,000 in operating costs—based on current utility rates—over the appliances' lifetimes.

The purchase was stimulated by the NBS Experimental Technology Incentives Program (ETIP) which is working with the Federal Supply Service (FSS) of the General Services Administration.

The home hot water heaters were purchased for military housing units under a $817,000 contract with the A. O. Smith Corporation of Kankakee, Ill. These heaters, which have more efficient heating units and heavier insulation, were previously marketed mainly in France where energy costs have always been higher than in the United States.

G. A. Buckman, product manager for A. O. Smith, told ETIP officials that his company will begin marketing the heaters commercially in the United States as a result of winning the Federal contract.

ETIP was begun in fiscal 1973 as a means of stimulating private and government investment in research and development. By the end of this fiscal year ETIP will have committed $10 million to cooperative projects with other government agencies and to policy studies. ETIP is housed in the National Bureau of Standards.

This is one of several experimental purchases sponsored jointly by the FSS and ETIP. Dr. Jordan D. Lewis, director of ETIP, said the contract award demonstrates the ability of American industry to respond effectively to a Government market for innovative technology.

With the assistance of $30,000 "seed money" from ETIP, FSS asked industry to compete for the hot water heater contract on the basis of life cycle cost (LCC). LCC analyzes the lifetime ownership costs of an appliance as well as its initial purchase price. Such "life cycle costing" analysis will indicate whether a low initial purchase price may be offset by higher operating costs over the life of the applicance, says Lewis.

Because the hot water heaters ordered are better insulated than those the government bought in the past, less natural gas and electricity will be required to maintain acceptable temperatures for the water, noted Lewis. The increased efficiency of the insulation, burners and electric heating elements in these hot water heaters, said Lewis, will help the government conserve energy and reduce its fuel bill. The order includes 6,100 gas water heaters and 1,600 electric water heaters.

"Because the Federal Supply Service intends to apply life cycle costing that emphasizes energy efficiency in the procurement of hot water heaters and other appliances over the next several years, the effect on Federal energy consumption should be significant and, because the General Services Administration is creating a Federal market for energy efficient appliances, the appearance of these energy-saving appliances in the general consumer market should be accelerated," said Lewis. □

Pressure Transducer Service Available

NBS is now offering a Pressure Transducer Characterization Service to aid in the characterization of the long term performance of transducers.

Pressure transducers are used extensively in industry, science and government to transfer accurate measurements, control operational parameters, and monitor or test equipment or products. Many of these applications depend critically on the long term performance of the transducers.

Transducers submitted for the new NBS service will undergo a battery of tests for a period of 8 months to determine the following parameters, among others:

- Warm-up time
- Zero drift
- Dependence on operational parameters
- Pressure and temperature hyteresis
- Relaxation
- Long and short term stability
- Precision
- Temperature effects on zero and span
- Effects on pressure cycling
- Attitude dependence

Pressure transducers for the range 0 to 140 kPa (0 to 20 psi), gage or absolute; and 0 to 4.2 MPa (0 to 600 psi) can be submitted.

Each transducer will be fully characterized and calibrated after this series of tests. An extensive report containing raw and evaluated data will be delivered to the submitter of the transducer after the testing is completed.

The first run will begin October 1, 1975, and further tests will be run annually. The cost is $1,500 for the first transducer and $400 for each additional transducer of the same type and range covered by one order.

A short report describing the test schedule is available from the Pressure and Vacuum Section, NBS, Metrology A149, Washington, D.C. 20234. For additional information, contact Dr. V. Bean, 301/921-2121. □

Measuring Lead in Auto Fuels

NBS has developed three new Standard Reference Materials (SRM's) for the determination of lead in motor fuel.

The new SRM's allow fuel producers, consumers and regulatory agencies to refer their measurements of lead in fuel to a common, agreed-upon basis. Using the SRM's, any disagreements in measurements can be resolved, since the SRM lead values have been measured and certified as being accurate. In addition, measurement scientists can correct systematic differences in the various analytical methods used in testing for lead.

Organic lead compounds have been added to motor fuel for the past 50 years to improve its combustion characteristics or octane number. In recent years, however, there has been growing concern over the amount of lead entering the atmosphere through automobile exhaust. To reduce the trend of leaded gasoline—and lead in the atmosphere—the Environmental Protection Agency has gradually decreased the amount of lead permitted in gasoline.

All American cars built since 1971 *can* operate on unleaded gasoline. Most 1975 American cars *must* use unleaded gasoline since leaded gas can make catalytic converters, emission control devices required on these cars, unable to convert pollutants into nonpolluting by-products.

The SRM's consist of units of 12 ampoules, each of which contains 20 milliliters of leaded fuel. Initially, NBS chemists prepared four separate blends of leaded fuel of nominal concentrations 0.03, 0.05, 0.07, and 2.0 grams lead per gallon. The SRM units are made up of various combinations of these concentrations.

SRM 1636 contains three ampoules of each concentration. SRM 1637 contains four ampoules each of the three lowest concentrations, and SRM 1638 contains 12 ampoules of the 2.0 grams/gallon concentrations.

Because the volume of the reference material varies with temperature, the various concentrations of lead are certified by weight, that is, micrograms of lead per gram of fuel. For convenience, information is also given for the concentration in grams per gallon and grams per liter at 20°C and 25°C. The labels on the individual ampoules bear the lead concentration in grams per gallon at 20°C.

Standard Reference Materials 1636, 1637, and 1638 may be ordered from the Office of Standard Reference Materials, B311 Chemistry Building, NBS, Washington, D.C. 20234. The price is $59.00 per unit of 12 ampoules. □

had broken in two was sent to NBS for analysis. Through careful laboratory procedures it was determined that the sample met Association of American Railroads (AAR) requirements for chemical composition, minimum yield point, and minimum elongation. The sample slightly exceeded the specified maximum tensile strength, but it failed the bend requirements.

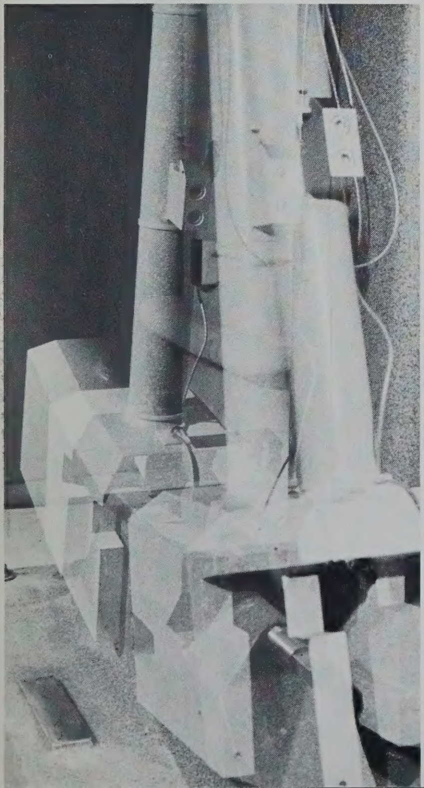
Impact tests indicated certain relatively low energy-absorption values when compared with other conventionally melted steels at the same strength level. These shelf energy values were related to the laminated fracture appearances, the sulfur level, the length of inclusions, and the microstructure of the steel.

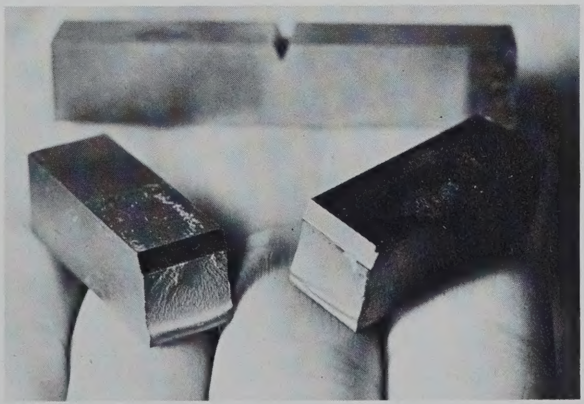
In the light of these and related technical findings, the Bureau's specialists suggested a fresh line of attack on the problem of inadequate resistance to circumferential fractures. A detailed review of tank car design was recommended, centering on realistic allowances for the characteristic known as anisotropy—that is, nonuniformity of mechanical properties measured along different directions in the material.

Along with the search for improved steels and better design principles, FRA is orchestrating tests and analyses of experimental tank coatings that might "give firefighters a fighting chance." In one of the White Sands Missile Range tests, for example, a protectively coated tank car took about four times longer to rupture under heat stress than did an uncoated tank car (94½ and 24½ minutes, respectively). In an actual occurrence, the time gained could mean significant saving of life and property. In addition, the type of fracture that occurred in the insulated car was one that would be less damaging. Fewer fragments were formed and they were propelled for shorter distances.

Members of the NBS Mechanical Properties Section participated in field investigations at White Sands and later performed analyses of 45 metal specimens taken from plate samples of the full-size insulated tank car that was tested to destruction. The Bureau's analysis of resulting data—based on chemical tests, hardness surveys, thickness measurements, macroscopic observations, and metallographic analyses—is helping to illuminate a little-explored area that is pivotal in the FRA research program. Knowledge of the elevated-temperature mechanical properties of tank car steels, and of the failure behavior of tank cars carrying compressed gases threatened by fire, is what the investigation is all about. NBS metallurgical and chemical findings will be incorporated into the basic body of data to be used by FRA in formulating revised standards governing the manufacture, materials, and design of America's railroad tank cars.

For the people of Docena or Crescent City or other places within reach of a railroad, these NBS technical studies will have future significance as the freight trains continue coursing along the arteries of our economy. □





In a Charpy V-notch impact test at NBS, the weighted pendulum delivers a powerful blow to a small steel specimen. Before and after specimens are shown on right.

AN EQUAL OPPORTUNITY EMPLOYER

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington D.C. 20234

OFFICIAL BUSINESS
Penalty for Private Use, $300
RETURN POSTAGE GUARANTEED

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-215

U.S.MAIL

THIRD CLASS MAIL

PUBLICATIONS

of the National Bureau of Standards

Electronic Technology

Bullis, W. M., Ed., *Semiconductor Measurement Technology: Quarterly Report, July 1 to September 30, 1974,* Nat. Bur. Stand. (U.S.), Spec. Publ. 400-12, 59 pages (May 1975) SD Catalog No. C13.10:400-12, $1.15.

Mattis, R. L., and Buehler, M. G., *Semiconductor Measurement Technology; A BASIC Program for Calculating Dopant Density Profiles from Capacitance-Voltage Data,* Nat. Bur. Stand. (U.S.), Spec. Publ. 400-11, 39 pages (June 1975) SD Catalog No. C13.10:400-11, $1.00.

Energy Conservation and Production

Kusuda, T., Ed., *Underground Heat and Chilled Water Distribution Systems,* Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 66, 146 pages (May 1975) SD Catalog No. C13.29:2/66, $2.10.

Fluids: Liquids, Gases and Plasmas

Kulin, G., and Compton, P. R., *A Guide to Methods and Standards for the Measurement of Water Flow,* Nat. Bur. Stand. (U.S.), Spec. Publ. 421, 97 pages (May 1975) SD Catalog No. C13.10:421, $1.65.

Measurement Science and Technology

Ashby, N., *An Earth-Based Coordinate Clock Network,* Nat. Bur. Stand. (U.S.), Tech. Note 659, 34 pages (Apr. 1975) SD Catalog No. C13.46:659, 85 cents.

Metrology: Physical Measurements

Schooley, J. F., Ed., *Temperature Section Activity Summary, 1974.* Nat. Bur. Stand. (U.S.), Tech. Note 869, 28 pages (June 1975) SD Catalog No. C13.46:869, 80 cents.

Standard Reference Data

Ross, A. R., *Selected Specific Rates of Reactions of Transients from Water in Aqueous Solution. Hydrated Electron, Supplemental Data,* Nat. Stand. Ref. Data. Ser., Nat. Bur. Stand. (U.S.), 43, Suppl., 43 pages (June 1975) SD Catalog No. C13.48:43, Suppl., $1.10.

Publications listed here may be purchased at the listed price from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (foreign: add 25%). Microfiche copies are available from the National Technical Information Service, Springfield, Va. 22151. For more complete periodic listings of all scientific papers and articles produced by NBS staff, write: Editor, Publications Newsletter, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

Subscription Order Form

ENTER MY SUBSCRIPTION TO DIMENSIONS/NBS (formerly the NBS Technical News Bulletin) (C13.13) at $9.45. Add $2.40 for foreign mailing. No additional postage is required for mailing within the United States or its possessions.

Send subscription to:

NAME—FIRST, LAST

COMPANY NAME OR ADDITIONAL ADDRESS LINE

STREET ADDRESS

CITY | STATE | ZIP CODE

PLEASE PRINT

☐ Remittance enclosed (Make checks payable to Superintendent of Documents)

☐ Charge to my Deposit Account No.

MAIL ORDER FORM TO:

Superintendent of Documents
Government Printing Office
Washington, D.C. 20402